Mobile telephony

History

Anders Dernback
Text Wikipedia

7,950,000,000

In use in

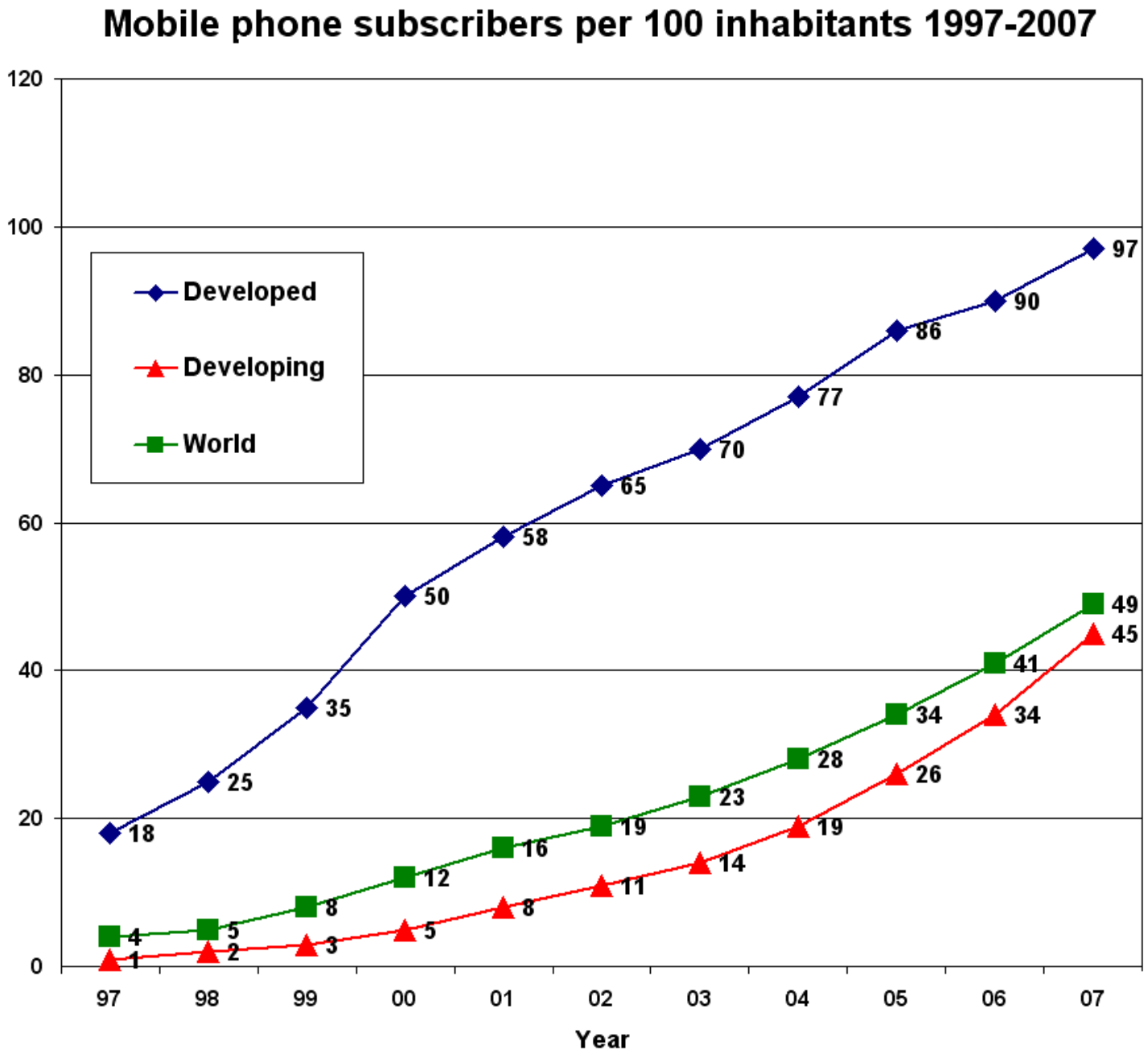
World

1,610,360,000

In China

1,515,971,713

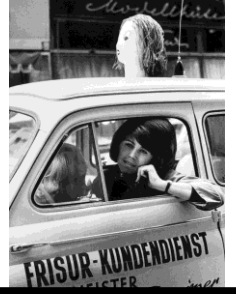
In India



Mobile phone subscriptions, not subscribers

per 100 inhabitants 1997-2007

Booth presenting the first Dutch vehicle or watercraft telephone ("Mobilofoon"), a collaboration of the Royal Dutch Automobile Club (KNAC), and the Netherlands Postal, Telegraph and Telephone (PTT) at the 1948 Amsterdam International Motor Show

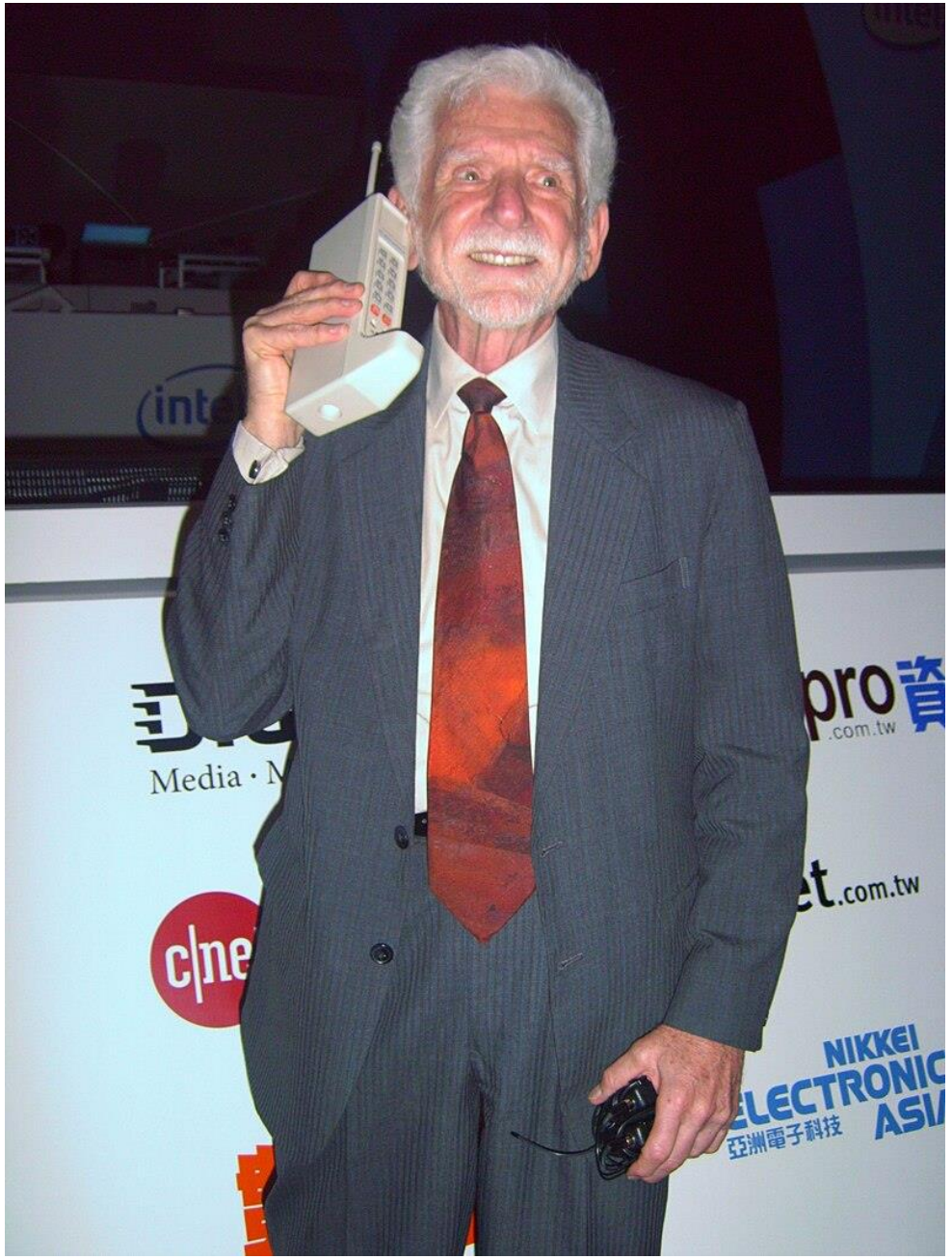


History of mobile telephony

A handheld mobile radio telephone service was envisioned in the early stages of radio engineering. In 1917, Finnish inventor Eric Tigerstedt filed a patent for a "pocket-size folding telephone with a very thin carbon microphone". Early predecessors of cellular phones included analog radio communications from ships and trains. The race to create truly portable telephone devices began after World War II, with developments taking place in many countries. The advances in mobile telephony have been traced in successive "generations", starting with the early zeroth-generation (0G) services, such as Bell System's Mobile Telephone Service and its successor, the Improved Mobile Telephone Service. These 0G systems were not cellular, supported a few simultaneous calls, and were very expensive.

The first handheld cellular mobile phone was demonstrated by John F. Mitchell and Martin Cooper of Motorola in 1973, using a handset weighing 2 kilograms (4.4 lb). The first commercial automated cellular network (1G) analog was launched in Japan by Nippon Telegraph and Telephone in 1979. This was followed in 1981 by the simultaneous launch of the Nordic Mobile Telephone (NMT) system in Denmark, Finland, Norway, and Sweden. Several other countries then followed in the early to mid-1980s. These first-generation (1G) systems could support far more simultaneous calls but still used analog cellular technology. In 1983, the DynaTAC 8000x was the first commercially available handheld mobile phone.

In 1991, the second-generation (2G) digital cellular technology was launched in Finland by Radiolinja on the GSM standard. This sparked competition in the sector as the new operators challenged the incumbent 1G network operators. The GSM standard is a European initiative expressed at the CEPT ("Conférence Européenne des Postes et Telecommunications", European Postal and Telecommunications conference). The Franco-German R&D cooperation demonstrated the technical feasibility, and in 1987, a Memorandum of Understanding was signed between 13 European countries that agreed to launch a commercial service by 1991. The first version of the GSM standard had 6,000 pages. The IEEE and RSE awarded Thomas Haug and Philippe Dupuis the 2018 James Clerk Maxwell medal for their contributions to the first digital mobile telephone standard. In 2018, the GSM was used by over 5 billion people in over 220 countries. The GSM (2G) has evolved into 3G, 4G and 5G. The standardization body for GSM started at the CEPT Working Group GSM (Group Special Mobile) in 1982 under the umbrella of CEPT. In 1988, ETSI was established, and all CEPT standardization activities were transferred to ETSI. Working Group GSM became Technical Committee GSM. In 1991, it became Technical Committee SMG (Special Mobile Group) when ETSI tasked the committee with UMTS (3G). In addition to transmitting voice over digital signals, the 2G network introduced data services for mobile, starting with SMS text messages, then expanding to Multimedia Messaging Service (MMS), and mobile internet with a theoretical maximum transfer speed of 384 kbit/s (48 kB/s).



Martin Cooper of Motorola, shown here in a 2007 reenactment, made the first publicized handheld mobile phone call on a prototype DynaTAC model on 3 April 1973.

In 2001, the third-generation (3G) was launched in Japan by NTT DoCoMo on the WCDMA standard. This was followed by 3.5G or 3G+ enhancements based on the high-speed packet access (HSPA) family, allowing UMTS networks to have higher data transfer speeds and capacity. 3G is able to provide mobile broadband access of several Mbit/s to smartphones and mobile modems in laptop computers. This ensures it can be applied to mobile Internet access, VoIP, video calls, and sending large e-mail messages, as well as watching videos, typically in standard-definition quality.

By 2009, it had become clear that, at some point, 3G networks would be overwhelmed by the growth of bandwidth-intensive applications, such as streaming media. Consequently, the industry began looking to data-optimized fourth-generation (4G) technologies, with the promise of speed improvements up to tenfold over existing 3G technologies. The first publicly available LTE service was launched in Scandinavia by TeliaSonera in 2009. In the 2010s, 4G technology has found diverse applications across various sectors, showcasing its versatility in delivering high-speed wireless communication, such as mobile broadband, the internet of things (IoT), fixed wireless access, and multimedia streaming (including music, video, radio, and television).

Mr Dupuis and Mr Haug during a GSM meeting in Belgium, April 1992

Nokia 6600 (2003) with a VGA camera, Bluetooth and expandable memory.

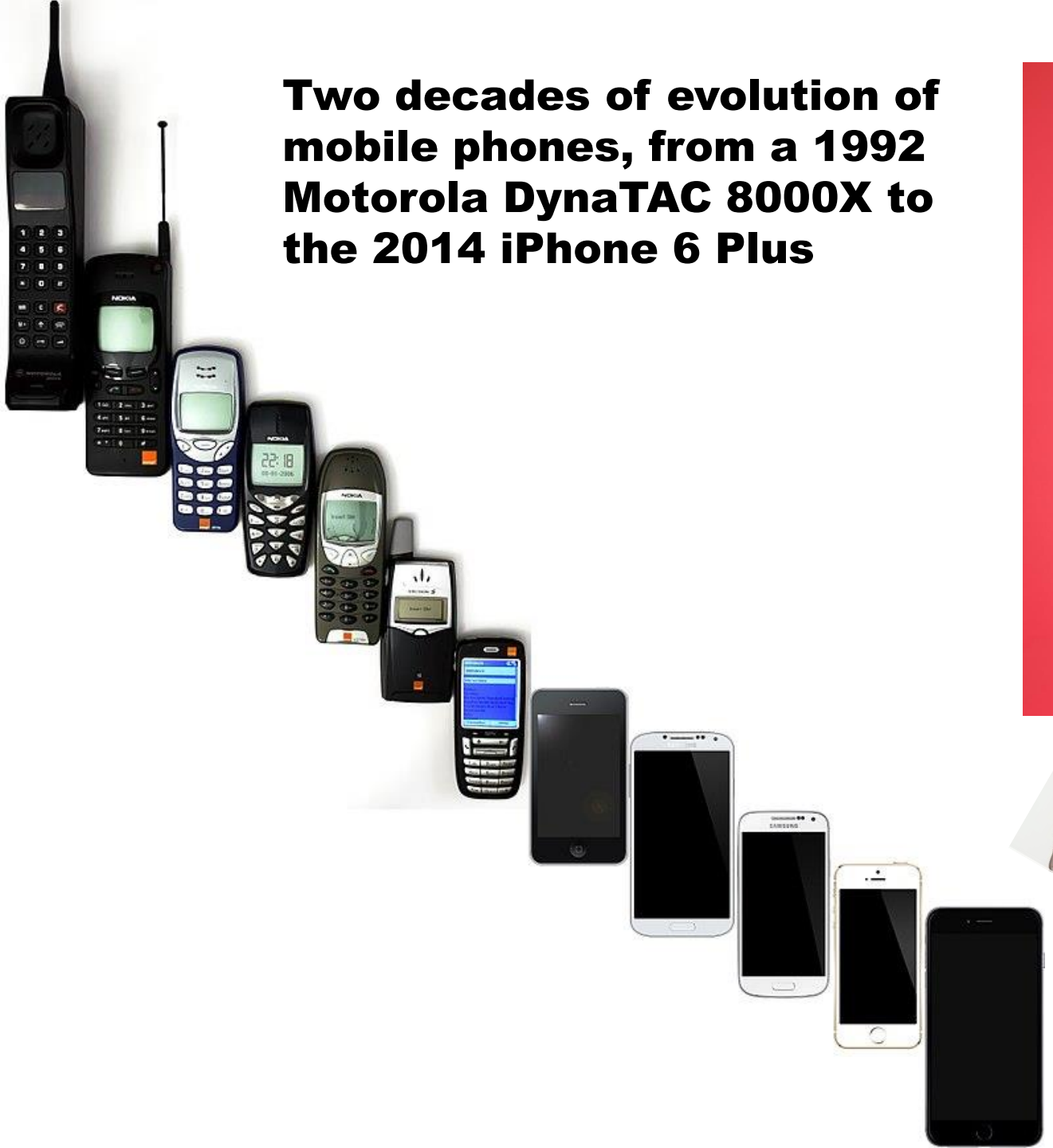
Nokia N73 (2006) with 3G and a front camera.

Nokia N95 (2007) with a 5-megapixel camera and sliding multimedia keys.

Nokia 5800 XpressMusic (2008), with a full touchscreen.

Nokia E71 (2008) with a QWERTY keyboard.

Two decades of evolution of mobile phones, from a 1992 Motorola DynaTAC 8000X to the 2014 iPhone 6 Plus



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Deployment of fifth-generation (5G) cellular networks commenced worldwide in 2019. The term "5G" was originally used in research papers and projects to denote the next major phase in mobile telecommunication standards beyond the 4G/IMT-Advanced standards. The 3GPP defines 5G as any system that adheres to the 5G NR (5G New Radio) standard. 5G can be implemented in low-band, mid-band or high-band millimeter-wave, with download speeds that can achieve gigabit-per-second (Gbit/s) range, aiming for a network latency of 1 ms. This near-real-time responsiveness and improved overall data performance are crucial for applications like online gaming, augmented and virtual reality, autonomous vehicles, IoT, and critical communication services.

Smartphones are defined by their advanced computing capabilities, which include internet connectivity and access to a wide range of applications. The International Telecommunication Union measures those with Internet connection, which it calls Active Mobile-Broadband subscriptions (which includes tablets, etc.). In developed countries, smartphones have largely replaced earlier mobile technologies, while in developing regions, they account for around 50% of all mobile phone usage.

Feature phone is a term typically used as a retronym to describe mobile phones which are limited in capabilities in contrast to a modern smartphone. Feature phones typically provide voice calling and text messaging functionality, in addition to basic multimedia and Internet capabilities, and other services offered by the user's wireless service provider. A feature phone has additional functions over and above a basic mobile phone, which is only capable of voice calling and text messaging. Feature phones and basic mobile phones tend to use a proprietary, custom-designed software and user interface. By contrast, smartphones generally use a mobile operating system that often shares common traits across devices.

The critical advantage that modern cellular networks have over predecessor systems is the concept of frequency reuse allowing many simultaneous telephone conversations in a given service area. This allows efficient use of the limited radio spectrum allocated to mobile services, and lets thousands of subscribers converse at the same time within a given geographic area. A cellular network mobile phone system gets its name from dividing the service area into many small cells, each with a base station with (for example) a useful range on the order of a kilometer (mile). These systems have dozens or hundreds of possible channels allocated to them.

Automation embedded in the customer's handset and in the base stations control all phases of the call, from detecting the presence of a handset in a service area, temporary assignment of a channel to a handset making a call, interface with the land-line side of the network to connect to other subscribers, and collection of billing information for the service. In order to handle the high traffic, multiple towers can be set up in the same area (using different frequencies). This can be done permanently or temporarily such as at special events or in disasters. Cell phone companies will bring a truck with equipment to host the abnormally high traffic.

The common components found on all mobile phones are:

A central processing unit (CPU), the processor of phones. The CPU is a microprocessor fabricated on a metal–oxide–semiconductor (MOS) integrated circuit (IC) chip.
A battery, providing the power source for the phone functions. A modern handset typically uses a lithium-ion battery (LIB), whereas older handsets used nickel–metal hydride (Ni–MH) batteries.
An input mechanism to allow the user to interact with the phone. These are a keypad for feature phones, and touch screens for most smartphones (typically with capacitive sensing).
A display which echoes the user's typing, and displays text messages, contacts, and more. The display is typically either a liquid-crystal display (LCD) or organic light-emitting diode (OLED) display.
Speakers for sound.
Subscriber identity module (SIM) cards and removable user identity module (R-UIM) cards.
A hardware notification LED on some phones

Low-end mobile phones are often referred to as feature phones and offer basic telephony. Handsets with more advanced computing ability through the use of native software applications are known as smartphones.
Mobile phones have central processing units (CPUs), similar to those in computers, but optimised to operate in low power environments. One of the main characteristics of phones is the screen. Depending on the device's type and design, the screen fills most or nearly all of the space on a device's front surface. In sound, smartphones and feature phones vary little. Some audio-quality enhancing features, such as Voice over LTE and HD Voice, have appeared and are often available on newer smartphones.

The typical lifespan of a mobile phone battery is approximately two to three years, although this varies based on usage patterns, environmental conditions, and overall care. Most modern mobile phones use lithium-ion (Li-ion) batteries, which are designed to endure between 500 and 2,500 charge cycles. The exact number of cycles depends on factors such as charging habits, operating temperature, and battery management systems.

Li-ion batteries gradually degrade over time due to chemical aging, leading to reduced capacity and performance, often noticeable after one or two years of regular use. Unlike older battery types, such as nickel-metal hydride (Ni-MH), Li-ion batteries do not need to be fully discharged to maintain their longevity. In fact, they perform best when kept between 30% and 80% of their full charge.

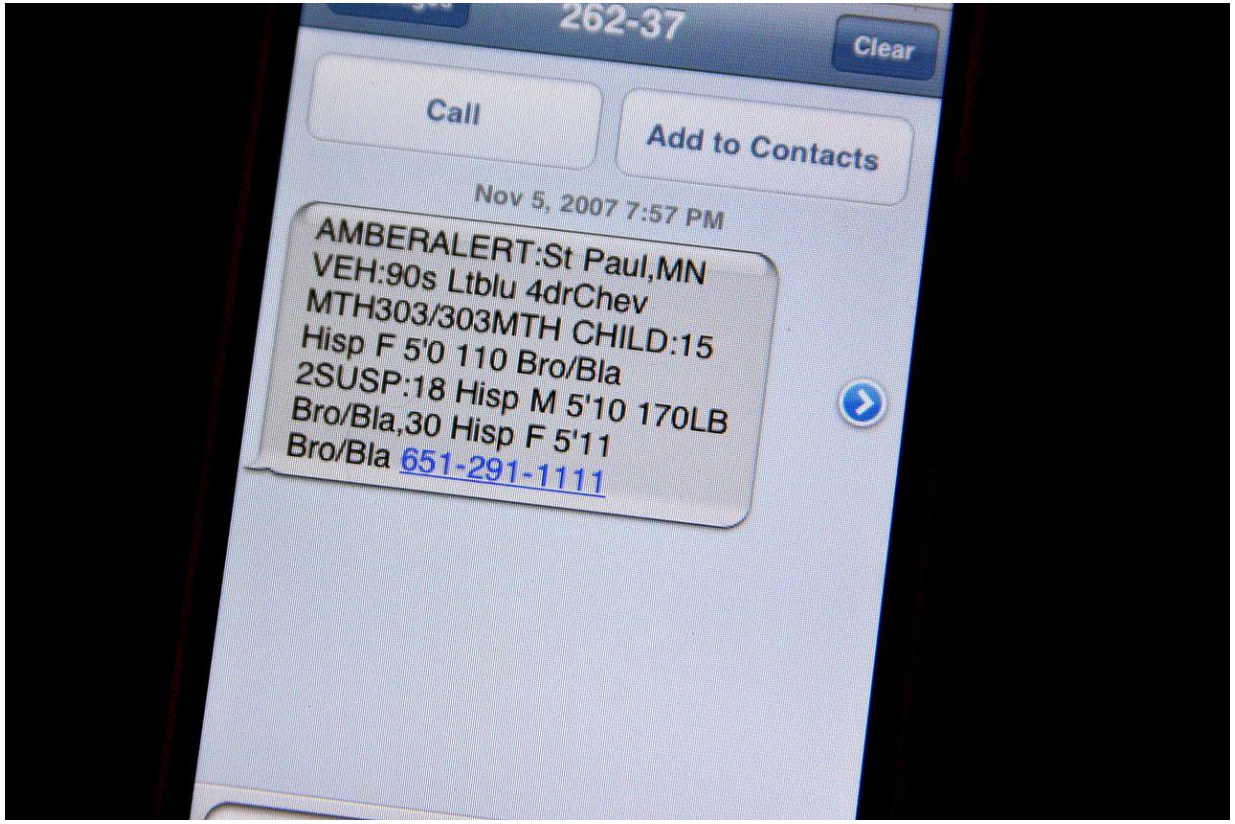
Future mobile phone batteries are expected to utilize advanced technologies such as silicon-carbon (Si/C) batteries and solid-state batteries, which promise to offer higher energy densities, longer lifespans, and improved safety compared to current lithium-ion batteries.

Nokia Li-ion Battery

Typical mobile phone mini-SIM card

Mobile phones require a small microchip called a Subscriber Identity Module or SIM card, in order to function. The SIM card is approximately the size of a small postage stamp and is usually placed underneath the battery in the rear of the unit. The SIM securely stores the service-subscriber key (IMSI) and the Ki used to identify and authenticate the user of the mobile phone. The SIM card allows users to change phones by simply removing the SIM card from one mobile phone and inserting it into another mobile phone or broadband telephony device, provided that this is not prevented by a SIM lock. The first SIM card was made in 1991 by Munich smart card maker Giesecke & Devrient for the Finnish wireless network operator Radiolinja.

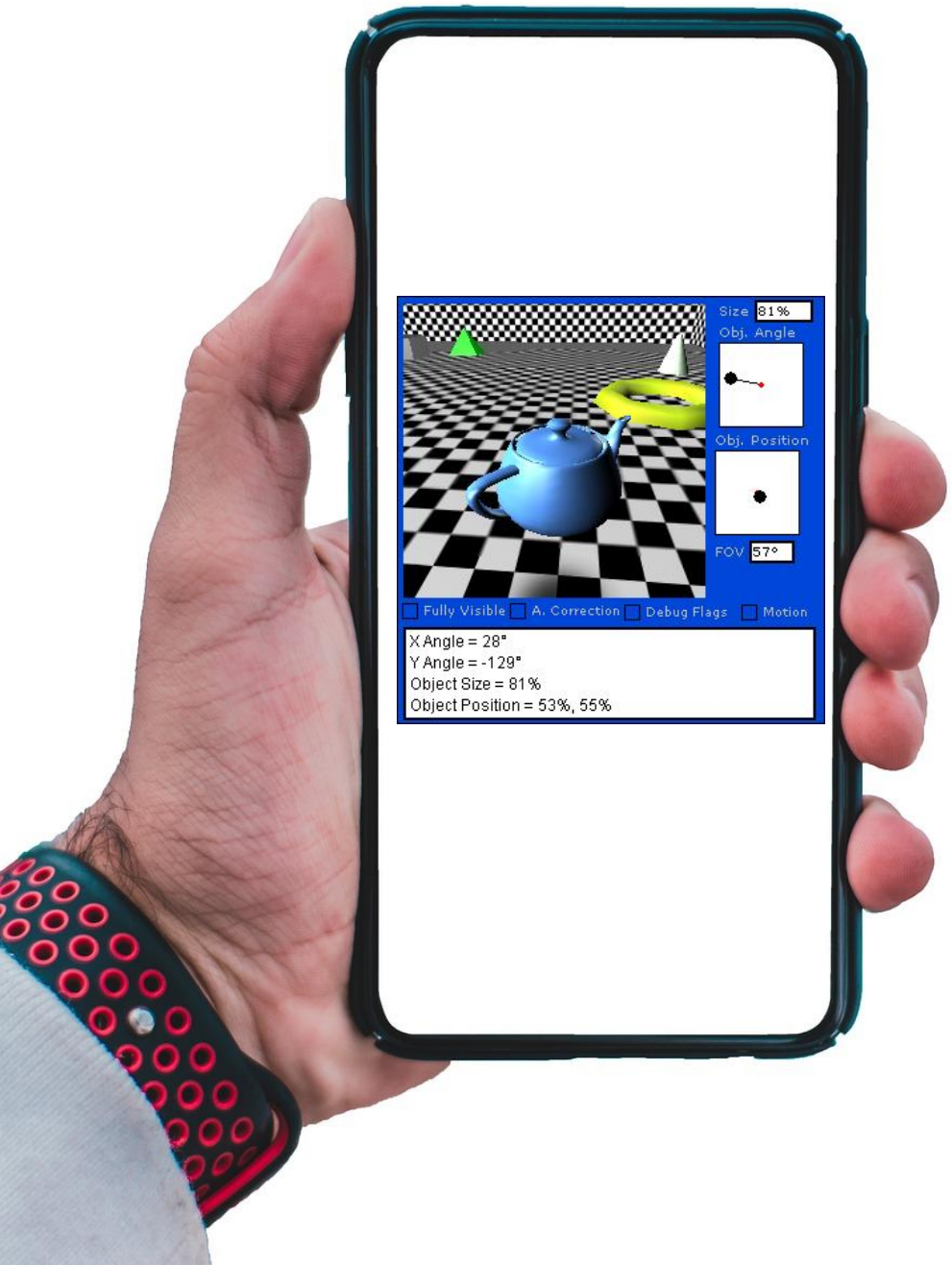
A hybrid mobile phone can hold up to four SIM cards, with a phone having a different device identifier for each SIM Card. SIM and R-UIM cards may be mixed together to allow both GSM and CDMA networks to be accessed. From 2010 onwards, such phones became popular in emerging markets, and this was attributed to the desire to obtain the lowest calling costs.



Android smartphones

A text message (SMS)

A common data application on mobile phones is Short Message Service (SMS) text messaging. The first SMS message was sent from a computer to a mobile phone in 1992 in the UK while the first person-to-person SMS from phone to phone was sent in Finland in 1993. The first mobile news service, delivered via SMS, was launched in Finland in 2000,[39] and subsequently many organizations provided "on-demand" and "instant" news services by SMS. Multimedia Messaging Service (MMS) was introduced in March 2002.



The introduction of Apple's App Store for the iPhone and iPod Touch in July 2008 popularized manufacturer-hosted online distribution for third-party applications (software and computer programs) focused on a single platform. There are a huge variety of apps, including video games, music products and business tools. Up until that point, smartphone application distribution depended on third-party sources providing applications for multiple platforms, such as GetJar, Handango, Handmark, and PocketGear. Following the success of the App Store, other smartphone manufacturers launched application stores, such as Google's Android Market (later renamed to the Google Play Store), RIM's BlackBerry App World, or Android-related app stores like Aptoide, Cafe Bazaar, F-Droid, GetJar, and Opera Mobile Store. In February 2014, 93% of mobile developers were targeting smartphones first for mobile app development.

The Mobira Cityman 150, Nokia's NMT-900 mobile phone from 1989 (left), compared to the Nokia 1100, a GSM phone from 200

From 1983 to 1998, Motorola was market leader in mobile phones. Nokia was the market leader in mobile phones from 1998 to 2012. In Q1 2012, Samsung surpassed Nokia, selling 93.5 million units as against Nokia's 82.7 million units. Samsung has retained its top position since then.

Aside from Motorola, European brands such as Nokia, Siemens and Ericsson once held large sway over the global mobile phone market, and many new technologies were pioneered in Europe. By 2010, the influence of European companies had significantly decreased due to fierce competition from American and Asian companies, to where most technical innovation had shifted. Apple and Google, both of the United States, also came to dominate mobile phone software. The world's largest individual mobile operator by number of subscribers is China Mobile, which has over 902 million mobile phone subscribers as of June 2018. Over 50 mobile operators have over ten million subscribers each, and over 150 mobile operators had at least one million subscribers by the end of 2009.

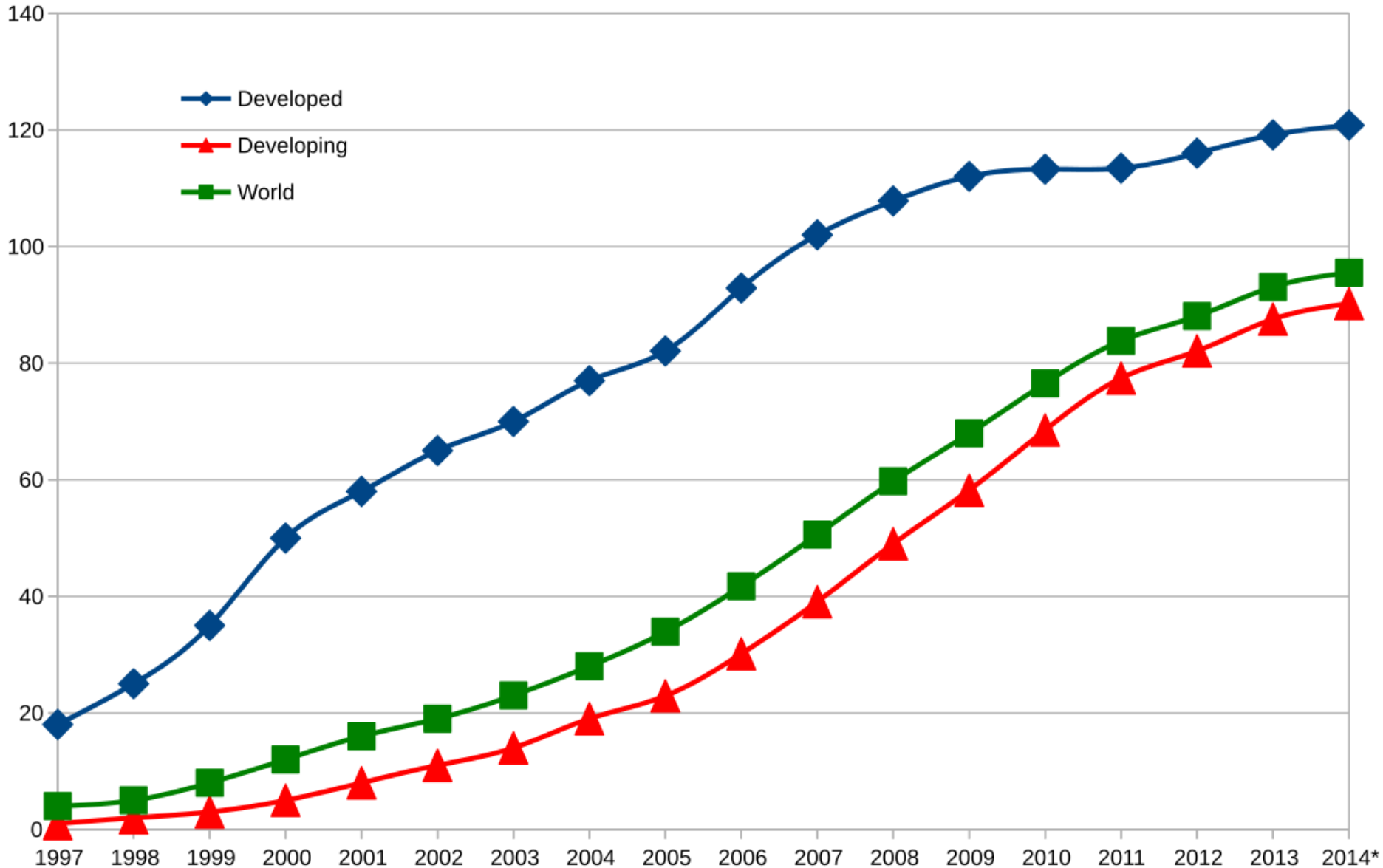
Reduction in size of Nokia mobile phones.
Left to right:

Nokia 638 (1996; 19.06 cm height),
Nokia 2160 EFR (1996; 16.42 cm),
Nokia 5160 (1998; 14.84 cm),
Nokia 6070

Back of the Samsung Galaxy S23 Cream (right), S23+ Lavender (center), and S23 Ultra Green (left)
Alcatel One Touch 535, front side (introduced July 2003)

In 1998, one of the first examples of distributing and selling media content through the mobile phone was the sale of ringtones by Radiolinja in Finland. Soon afterwards, other media content appeared, such as news, video games, jokes, horoscopes, TV content and advertising. Most early content for mobile phones tended to be copies of legacy media, such as banner advertisements or TV news highlight video clips. Recently, unique content for mobile phones has been emerging, from ringtones and ringback tones to mobisodes, video content that has been produced exclusively for mobile phones. In many countries, mobile phones are used to provide mobile banking services, which may include the ability to transfer cash payments by secure SMS text message. Mobile payments were first trialled in Finland in 1998 when two Coca-Cola vending machines in Espoo were enabled to work with SMS payments.

Mobile phone subscribers per 100 inhabitants 1997-2014



Mobile phones are commonly used to collect location data. While the phone is turned on, the geographical location of a mobile phone can be determined easily (whether it is being used or not) using a technique known as multilateration to calculate the differences in time for a signal to travel from the mobile phone to each of several cell towers near the owner of the phone

Hackers have been able to track a phone's location, read messages, and record calls, through obtaining a subscribers phone number.

According to the Federal Communications Commission, one out of three robberies involve the theft of a cellular phone. Police data in San Francisco show that half of all robberies in 2012 were thefts of cellular phones.

In 2010, an estimated 1500 pedestrians were injured in the US while using a cellphone and some jurisdictions have attempted to ban pedestrians from using their cellphones.

A study by the London School of Economics found that banning mobile phones in schools could increase pupils' academic performance, providing benefits equal to one extra week of schooling per year.

Mobile phones are considered an important human invention as it has been one of the most widely used and sold pieces of consumer technology. They have also become culturally symbolic. In Japanese mobile phone culture for example, mobile phones are often decorated with charms. They have also become fashion symbols at times. The Motorola Razr V3 and LG Chocolate are two examples of devices that were popular for being fashionable while not necessarily focusing on the original purpose of mobile phones, i.e. a device to provide mobile telephony.

Some have also suggested that mobile phones or smartphones are a status symbol. Text messaging, which are performed on mobile phones, has also led to the creation of 'SMS language'.

11:45 pm
Social
flickr

Alcatel One Touch 535, front side (introduced July 2003)

Back of the Samsung Galaxy S23 Cream (right), S23+ Lavender (center), and S23 Ultra Green (left)

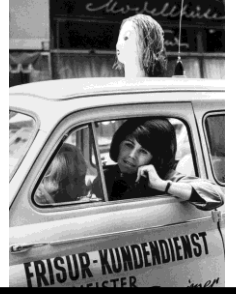
Samsung Galaxy S25 series Phone in Navy

The Samsung Galaxy S25 is a series of high-end Android-based smartphones developed, manufactured, and marketed by Samsung Electronics as part of its flagship Galaxy S Series. They collectively serve as the successor to the Samsung Galaxy S24 series. The S25, S25+ and S25 Ultra models were announced on January 22, 2025, at the Galaxy Unpacked event in San Jose, California and are expected to be released on February 7, 2025. Additionally, a phone called Galaxy S25 Edge was teased, however further details about the phone are not yet known.

Samsung S24 Ultra Phone

The Samsung Galaxy S24 is a series of high-end Android-based smartphones developed, manufactured, and marketed by Samsung Electronics as part of its flagship Galaxy S series. They collectively serve as the successor to the Galaxy S23 series. The phones were announced on January 17, 2024, at the Galaxy Unpacked event in San Jose, California and subsequently released on January 31, 2024. The S24 FE was announced on September 26, 2024, and was released on October 3, 2024. They were succeeded by the Galaxy S25 series announced on January 22, 2025.

A Wikipedia page on an Apple iPhone 2G displayed on the Safari web browser

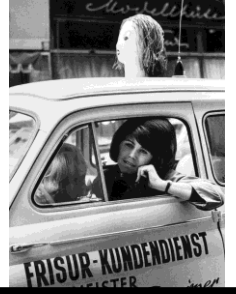


History of mobile telephony

Mobile telephony is the provision of wireless telephone services to mobile phones, distinguishing it from fixed-location telephony provided via landline phones. Traditionally, telephony specifically refers to voice communication, though the distinction has become less clear with the integration of additional features such as text messaging and data services.

Modern mobile phones connect to a terrestrial cellular network of base stations (commonly referred to as cell sites), using radio waves to facilitate communication. Satellite phones use wireless links to orbiting satellites, providing an alternative in areas lacking local terrestrial communication infrastructure, such as landline and cellular networks. Cellular networks, satellite networks, and landline systems are all linked to the public switched telephone network (PSTN), enabling calls to be made to and from nearly any telephone worldwide.

As of 2010, global estimates indicated approximately five billion mobile cellular subscriptions, highlighting the significant role of mobile telephony in global communication systems.

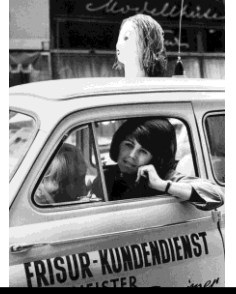


History of mobile telephony

According to internal memos, American Telephone & Telegraph discussed developing a wireless phone in 1915, but were afraid that deployment of the technology could undermine its monopoly on wired service in the U.S.

Booth presenting the first Dutch vehicle or watercraft telephone ("Mobilofoon"), a collaboration of the Royal Dutch Automobile Club (KNAC), and the Netherlands Postal, Telegraph and Telephone (PTT) at the 1948 Amsterdam International Motor Show (AutoRAI).
Public mobile phone systems were first introduced in the years after the Second World War and made use of technology developed before and during the conflict. The first system opened in St. Louis, Missouri, United States in 1946 whilst other countries followed in the succeeding decades. The UK introduced its 'System 1' manual radiotelephone service as the South Lancashire Radiophone Service in 1958.

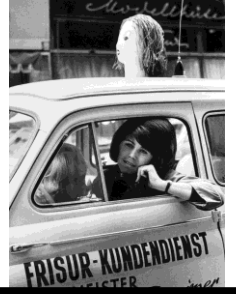
Calls were made via an operator using handsets identical to ordinary phone handsets.[3] The phone itself was a large box located in the boot (trunk) of the vehicle containing valves and other early electronic components.



History of mobile telephony

Although an uprated manual service ('System 3') was extended to cover most of the UK, automation did not arrive until 1981 with 'System 4'. Although this non-cellular service, based on German B-Netz technology, was expanded rapidly throughout the UK between 1982 and 1985 and continued in operation for several years before finally closing in Scotland, it was overtaken by the introduction in January 1985 of two cellular systems - the British Telecom/Securicor 'Cellnet' service and the Racal/Millicom/Barclays 'Vodafone' (from voice + data + phone) service. These cellular systems were based on US Advanced Mobile Phone Service (AMPS) technology, the modified technology being named Total Access Communication System (TACS).

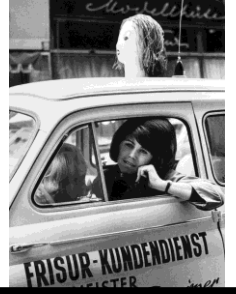
In 1947, Bell Labs was the first to propose a cellular radio telephone network. The primary innovation was the development of a network of small overlapping cell sites supported by a call switching infrastructure that tracks users as they move through a network and passes their calls from one site to another without dropping the connection.



History of mobile telephony

In 1956, the MTA system was launched in Sweden. The early efforts to develop mobile telephony faced two significant challenges: allowing a great number of callers to use the comparatively few available frequencies simultaneously and allowing users to seamlessly move from one area to another without having their calls dropped. Both problems were solved by Bell Labs employee Amos Joel who, in 1970 applied for a patent for a mobile communications system. However, a business consulting firm calculated the entire U.S. market for mobile telephones at 100,000 units and the entire worldwide market at no more than 200,000 units based on the ready availability of pay telephones and the high cost of constructing cell towers. As a consequence, Bell Labs concluded that the invention was "of little or no consequence," leading it not to attempt to commercialize the invention. The invention earned Joel induction into the National Inventors Hall of Fame in 2008.

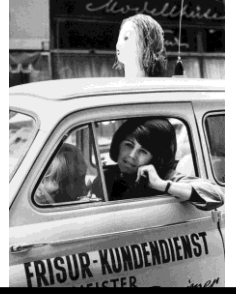
The development of metal–oxide–semiconductor (MOS) large-scale integration (LSI) technology, information theory and cellular networking led to the development of affordable mobile communications. The first call on a handheld mobile phone was made on April 3, 1973, by Martin Cooper, then of Motorola[7] to his opposite number in Bell Labs who were also racing to be first. Bell Labs went on to install the first trial cellular network in Chicago in 1978.



History of mobile telephony

This trial system was licensed by the FCC to ATT for commercial use in 1982 and, as part of the divestiture arrangements for the breakup of ATT, the AMPS technology was distributed to local telcos. The first commercial system opened in Chicago in October 1983. A system designed by Motorola also operated in the Washington D.C./Baltimore area from summer 1982 and became a full public service later the following year. Japan's first commercial radiotelephony service was launched by NTT in 1979.

The first fully automatic first generation cellular system was the Nordic Mobile Telephone (NMT) system, simultaneously launched in 1981 in Denmark, Finland, Norway and Sweden. NMT was the first mobile phone network featuring international roaming. The Swedish electrical engineer Östen Mäkitalo started to work on this vision in 1966, and is considered as the father of the NMT system and some also consider him the father of the cellular phone. Östen Mäkitalo (27 August 1938 – 16 June 2011) was a Swedish electrical engineer. He is considered to be one of the most important developers in modern times together with Laila Ohlgren, both engineers at Telia. Together they developed the Nordic Mobile Telephone (NMT) system and were the leading figures, representing Telia and Sweden, in the meetings with the other Nordic countries to find a common standard.

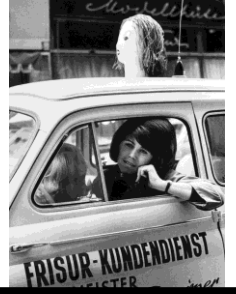


History of mobile telephony

Later they developed GSM and led the meetings to find a European and later world standard for mobile communication. They are many times considered the developer of the cellular phone and mobile telephony. There was a rapid growth of wireless telecommunications towards the end of the 20th century, primarily due to the introduction of digital signal processing in wireless communications, driven by the development of low-cost, very large-scale integration (VLSI) RF CMOS (radio-frequency complementary MOS) technology. The advent of cellular technology encouraged European countries to co-operate in the development of a pan-European cellular technology to rival those of the US and Japan.

This resulted in the GSM system, the initials originally from the Groupe Spécial Mobile that was charged with the specification and development tasks but latterly as the 'Global System for Mobile Communications'. The GSM standard eventually spread outside Europe and is now the most widely used cellular technology in the world and the de facto standard.

The industry association, the GSMA, now represents 219 countries and nearly 800 mobile network operators.



History of mobile telephony

There are now estimated to be over 5 billion phone subscriptions according to the "List of countries by number of mobile phones in use" (although some users have multiple subscriptions, or inactive subscriptions), which also makes the mobile phone the most widely spread technology and the most common electronic device in the world.

The first mobile phone to enable internet connectivity and wireless email, the Nokia Communicator, was released in 1996, creating a new category of multi-use devices called smartphones. In 1999 the first mobile internet service was launched by NTT DoCoMo in Japan under the i-Mode service. By 2007 over 798 million people around the world accessed the internet or equivalent mobile internet services such as WAP and i-Mode at least occasionally using a mobile phone rather than a personal computer. A cellular network or mobile network is a telecommunications network where the link to and from end nodes is wireless and the network is distributed over land areas called cells, each served by at least one fixed-location transceiver.

These sites are usually mounted on a tower, pole or building, located throughout populated areas, then connected to a cabled communication network and switching system. The phones have a low-power transceiver that transmits voice and data to the nearest cell sites, normally not more than 8 to 13 km (approximately 5 to 8 miles) away. In areas of low coverage, a cellular repeater may be used, which uses a long-distance high-gain dish antenna or yagi antenna to communicate with a cell tower far outside of normal range, and a repeater to rebroadcast on a small short-range local antenna that allows any cellphone within a few meters to function properly.

When the mobile phone or data device is turned on, it registers with the mobile telephone exchange, or switch, with its unique identifiers, and can then be alerted by the mobile switch when there is an incoming telephone call.

The handset constantly listens for the strongest signal being received from the surrounding base stations, and is able to switch seamlessly between sites. As the user moves around the network, the "handoffs" are performed to allow the device to switch sites without interrupting the call.

Cell sites have relatively low-power (often only one or two watts) radio transmitters which broadcast their presence and relay communications between the mobile handsets and the switch. The switch in turn connects the call to another subscriber of the same wireless service provider or to the public telephone network, which includes the networks of other wireless carriers. Many of these sites are camouflaged to blend with existing environments, particularly in scenic areas.

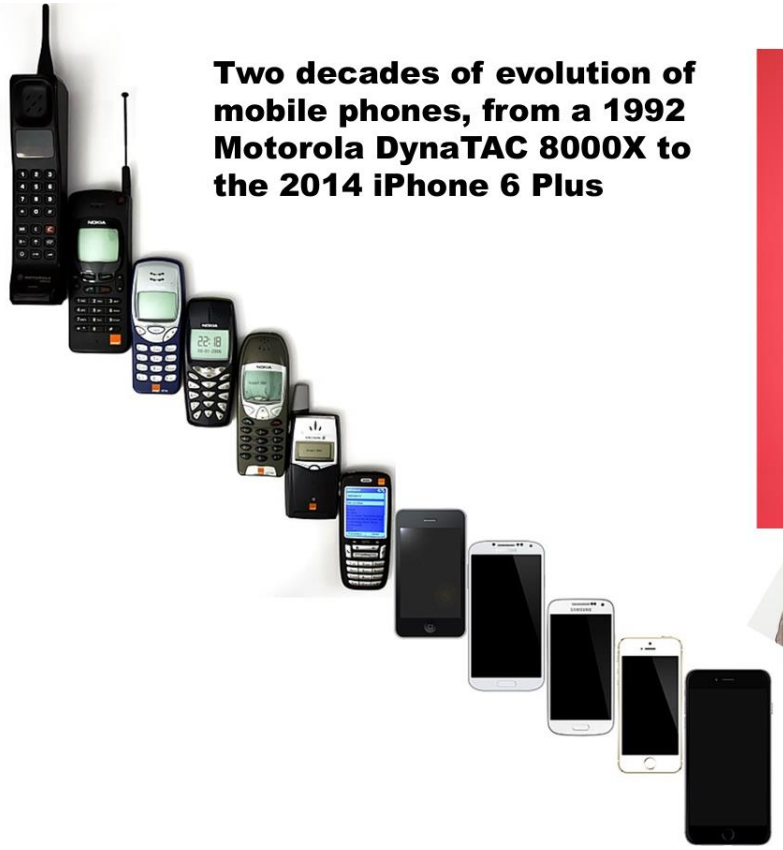
The dialogue between the handset and the cell site is a stream of digital data that includes digitised audio (except for the first generation analog networks). The technology that achieves this depends on the system which the mobile phone operator has adopted. The technologies are grouped by generation. The first-generation systems started in 1979 with Japan, are all analog and include AMPS and NMT. Second-generation systems, started in 1991 in Finland, are all digital and include GSM, CDMA and TDMA.

The GSM standard is a European initiative expressed at the CEPT ("Conférence Européenne des Postes et Telecommunications", European Postal and Telecommunications conference). The Franco-German R&D cooperation demonstrated the technical feasibility, and in 1987 a Memorandum of Understanding was signed between 13 European countries who agreed to launch a commercial service by 1991. The first version of the GSM (=2G) standard had 6,000 pages. The IEEE/RSE awarded to Thomas Haug and Philippe Dupuis the 2018 James Clerk Maxwell medal for their contributions to the first digital mobile telephone standard. In 2018, the GSM was used by over 5 billion people in over 220 countries. The GSM (2G) has evolved into 3G, 4G and 5G. The standardisation body for GSM started at the CEPT Working Group GSM (Group Special Mobile) in 1982 under the umbrella of CEPT. In 1988, ETSI was established and all CEPT standardization activities were transferred to ETSI. Working Group GSM became Technical Committee GSM. In 1991, it became Technical Committee SMG (Special Mobile Group) when ETSI tasked the committee with UMTS (3G).

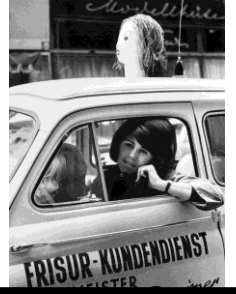
The nature of cellular technology renders many phones vulnerable to 'cloning': anytime a cell phone moves out of coverage (for example, in a road tunnel), when the signal is re-established, the phone sends out a 're-connect' signal to the nearest cell-tower, identifying itself and signalling that it is again ready to transmit. With the proper equipment, it is possible to intercept the re-connect signal and encode the data it contains into a 'blank' phone—in all respects, the 'blank' is then an exact duplicate of the real phone and any calls made on the 'clone' will be charged to the original account. This problem was widespread with the first generation analogue technology, however the modern digital standards such as GSM greatly improve security and make cloning hard to achieve. In an effort to limit the potential harm from having a transmitter close to the user's body, the first fixed/mobile cellular phones that had a separate transmitter, vehicle-mounted antenna, and handset (known as car phones and bag phones) were limited to a maximum 3 watts Effective Radiated Power.

History of mobile telephony

Modern handheld cellphones which must have the transmission antenna held inches from the user's skull are limited to a maximum transmission power of 0.6 watts ERP. Regardless of the potential biological effects, the reduced transmission range of modern handheld phones limits their usefulness in rural locations as compared to car/bag phones, and handhelds require that cell towers are spaced much closer together to compensate for their lack of transmission power.



Two decades of evolution of mobile phones, from a 1992 Motorola DynaTAC 8000X to the 2014 iPhone 6 Plus



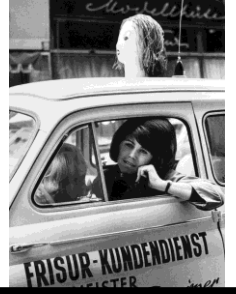
History of mobile telephony

An increasing number of countries, particularly in Europe, now have more mobile phones than people. According to the figures from Eurostat, the European Union's in-house statistical office, Luxembourg had the highest mobile phone penetration rate at 158 mobile subscriptions per 100 people, closely followed by Lithuania and Italy. In Hong Kong the penetration rate reached 139.8% of the population in July 2007. Over 50 countries have mobile phone subscription penetration rates higher than that of the population and the Western European average penetration rate was 110% in 2007 (source Informa 2007). There are over five hundred million active mobile phone accounts in China, as of 2007, but the total penetration rate there still stands below 50%. The total number of mobile phone subscribers in the world was estimated at 2.14 billion in 2005. The subscriber count reached 2.7 billion by end of 2006 according to Information.

This Railfone found on some Amtrak trains in North America uses cellular technology.

3.3 billion by November, 2007, thus reaching an equivalent of over half the planet's population. Around 80% of the world's population has access to mobile phone coverage, as of 2006. This figure is expected to increase to 90% by 2010.
In some developing countries with little "landline" telephone infrastructure, mobile phone use has quadrupled in the last decade. The rise of mobile phone technology in developing countries is often cited as an example of the leapfrog effect. Many remote regions in the third world went from having no telecommunications infrastructure to having satellite based communications systems. At present, Africa has the largest growth rate of cellular subscribers in the world, its markets expanding nearly twice as fast as Asian markets. The availability of prepaid or 'pay-as-you-go' services, where the subscriber is not committed to a long-term contract, has helped fuel this growth in Africa as well as in other continents.

On a numerical basis, India is the largest growth market, adding about 6 million mobile phones every month. It currently has a mobile subscriber base of 937.06 million mobile phones.



History of mobile telephony

Traffic

Since the world is operating quickly to 3G and 4G networks, mobile traffic through video is heading high. It is expected that by the end of 2018, the global traffic will reach an annual rate of 190 exabytes/year. This is the result of people shifting to smartphones. It is predicted by 2018, mobile traffic will reach by 10 billion connections with 94% traffic comes from smartphones, laptops and tablets. Also 69% of mobile traffic will be from videos since we have high definition screens available in smart phones and 176.9 wearable devices to be at use. Apparently, 4G will be dominating the traffic by 51% of total mobile data by 2018.

Lawful interception

Lawful interception (LI) refers to the facilities in telecommunications and telephone networks that allow law enforcement agencies with court orders or other legal authorization to selectively wiretap individual subscribers. Most countries require licensed telecommunications operators to provide their networks with Legal Interception gateways and nodes for the interception of communications.

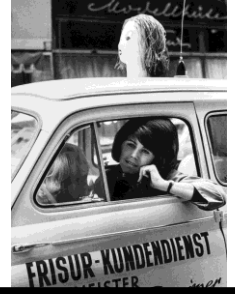
The interfaces of these gateways have been standardized by telecommunication standardization organizations. As with many law enforcement tools, LI systems may be subverted for illicit purposes.

With the legacy public switched telephone network (PSTN), wireless, and cable systems, lawful interception (LI) was generally performed by accessing the mechanical or digital switches supporting the targets' calls. The introduction of packet-switched networks, softswitch technology, and server-based applications during the past two decades fundamentally altered how LI is undertaken.

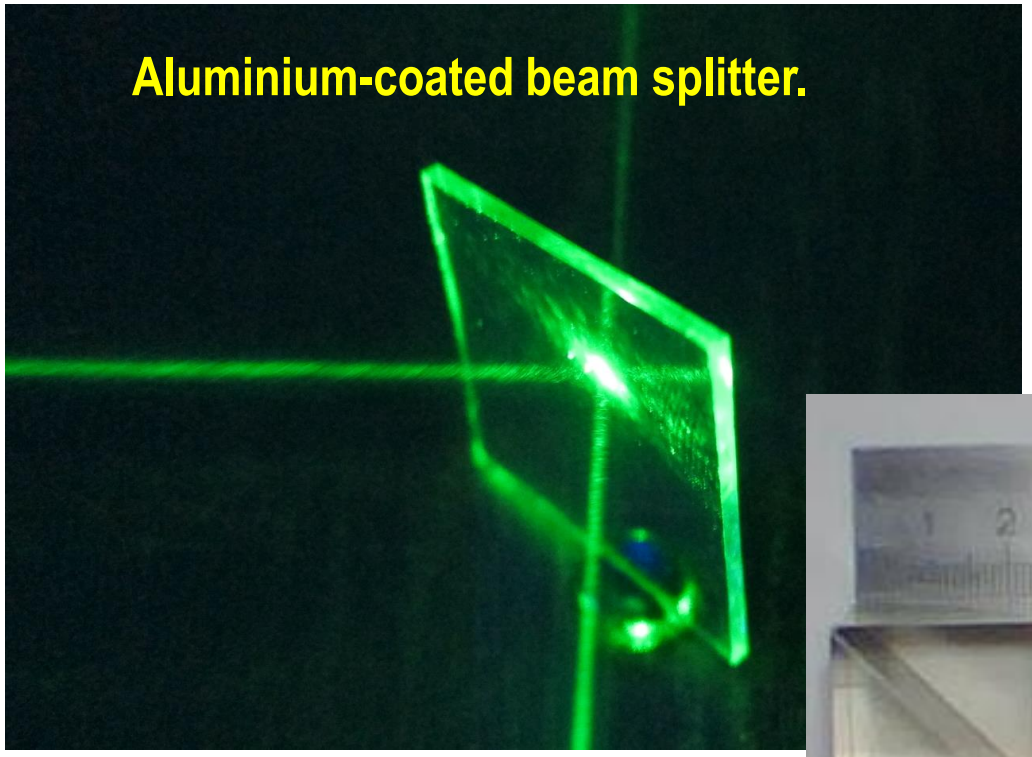
Lawful interception differs from the dragnet-type mass surveillance sometimes done by intelligence agencies, where all data passing a fiber-optic splice or other collection point is extracted for storage or filtering. It is also separate from the data retention of metadata that has become a legal requirement in some jurisdictions.

The SIS Building, headquarters of MI6, in London, United Kingdom

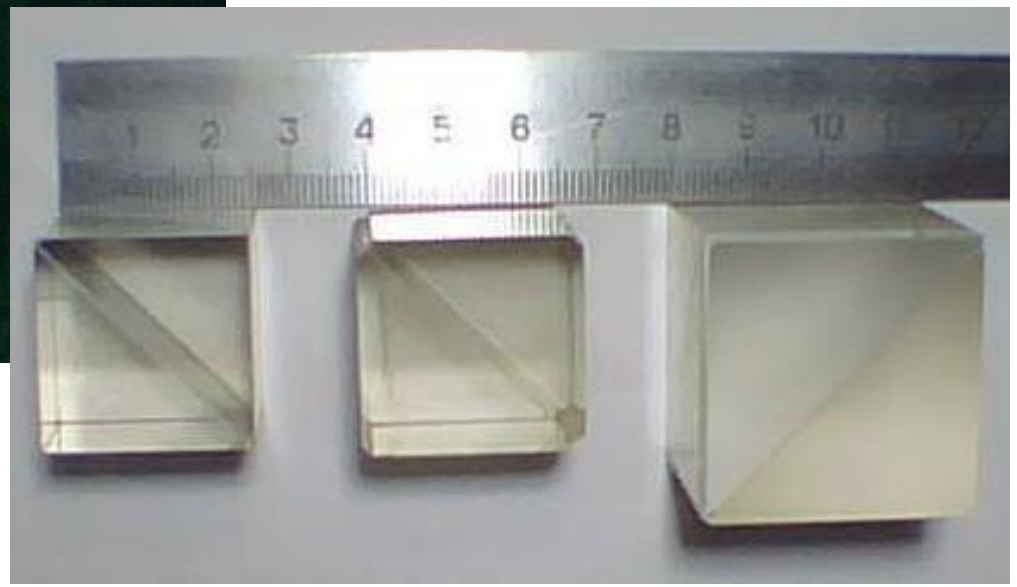
The Secret Intelligence Service (SIS), commonly known as MI6 (Military Intelligence, Section 6), is the foreign intelligence service of the United Kingdom, tasked mainly with the covert overseas collection and analysis of human intelligence on foreign nationals in support of its Five Eyes partners.



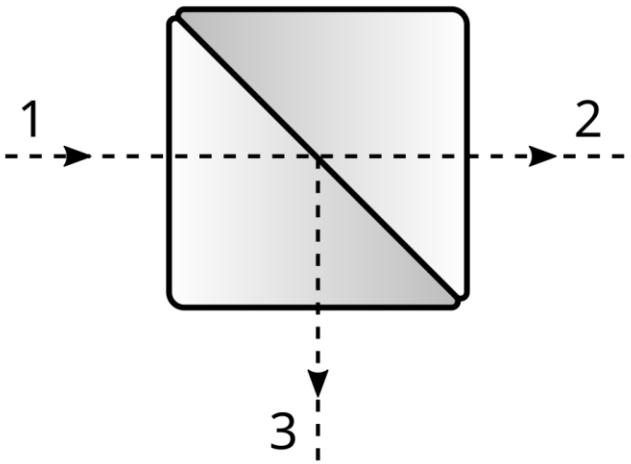
History of mobile telephony

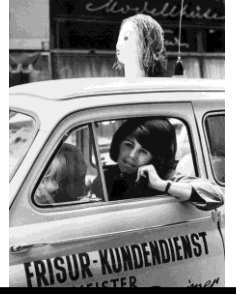


Schematic illustration of a beam splitter cube. 1 - Incident light 2 - 50% transmitted light 3 - 50% reflected light In practice, the reflective layer absorbs some light.



Beam splitters





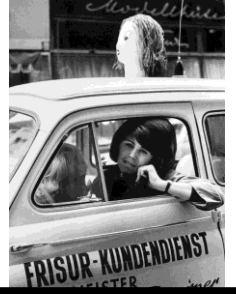
History of mobile telephony

Mass surveillance is the intricate surveillance of an entire or a substantial fraction of a population in order to monitor that group of citizens.

The surveillance is often carried out by local and federal governments or governmental organizations, but it may also be carried out by corporations (either on behalf of governments or at their own initiative). Depending on each nation's laws and judicial systems, the legality of and the permission required to engage in mass surveillance varies. It is the single most indicative distinguishing trait of totalitarian regimes. It is often distinguished from targeted surveillance.

Mass surveillance has often been cited as necessary to fight terrorism, prevent crime and social unrest, protect national security, and control the population. At the same time, mass surveillance has equally often been criticized for violating privacy rights, limiting civil and political rights and freedoms, and being illegal under some legal or constitutional systems. Another criticism is that increasing mass surveillance could potentially lead to the development of a surveillance state, an electronic police state, or a totalitarian state wherein civil liberties are infringed or political dissent is undermined by COINTELPRO-like programs

In 2013, the practice of mass surveillance by world governments was called into question after Edward Snowden's 2013 global surveillance disclosure on the practices by the National Security Agency (NSA) of the United States. Reporting based on documents Snowden leaked to various media outlets triggered a debate about civil liberties and the right to privacy in the Digital Age. Mass surveillance is considered a global issue. The Aerospace Corporation of the United States describes a near-future event, the GEOINT Singularity, in which everything on Earth will be monitored at all times, analyzed by artificial intelligence systems, and then redistributed and made available to the general public globally in real time



History of mobile telephony

The right to privacy is a highly developed area of law in Europe. The Data Protection Directive used to regulate the processing of personal data within the European Union, before it was replaced by the GDPR. For comparison, the US has no data protection law that is comparable to this; instead, the US regulates data protection on a sectoral basis.

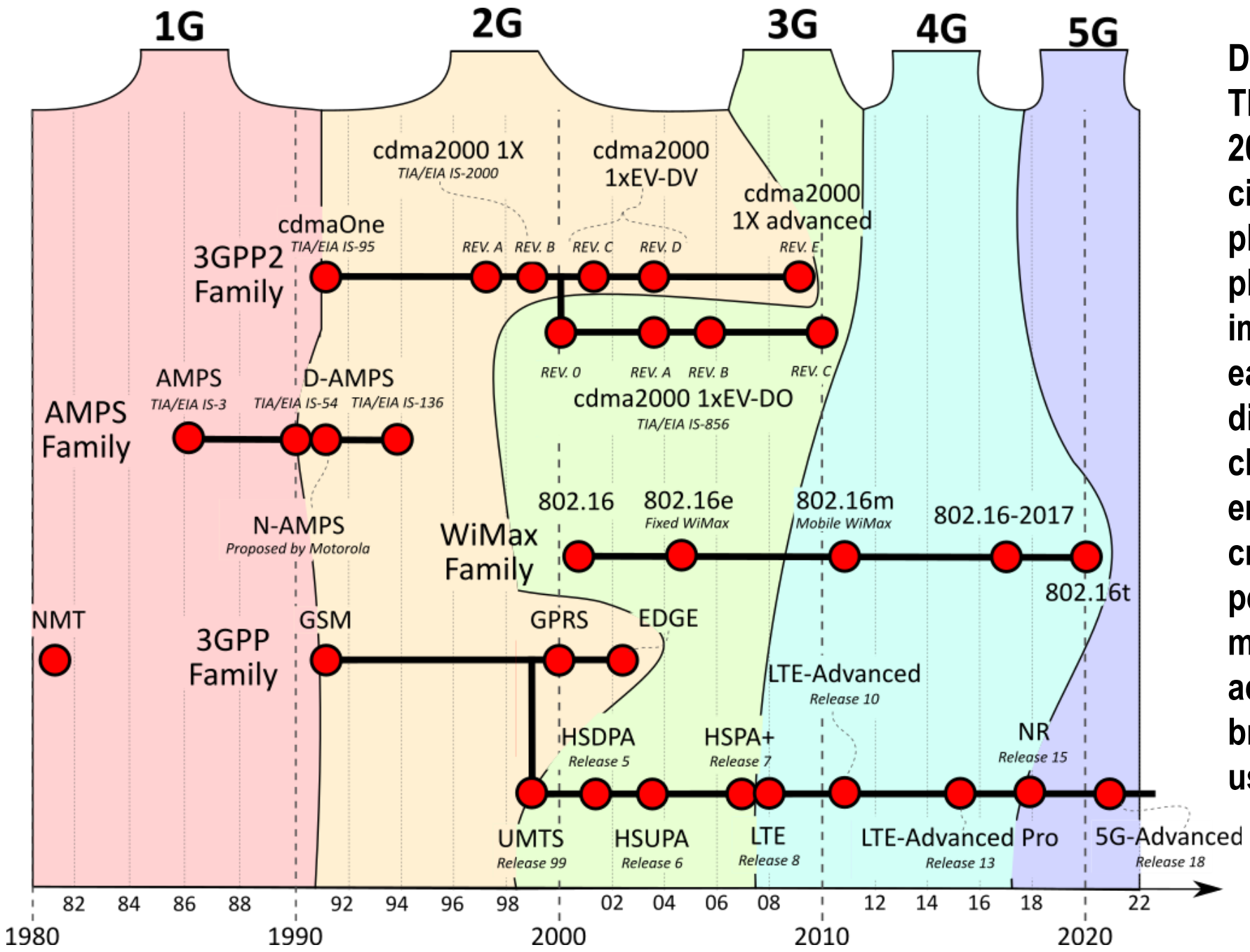
Since early 2012, the European Union has been working on a General Data Protection Regulation to replace the Data Protection Directive and harmonise data protection and privacy law. On 20 October 2013, a committee at the European Parliament backed the measure, which, if it is enacted, could require American companies to seek clearance from European officials before complying with United States warrants seeking private data. The vote is part of efforts in Europe to shield citizens from online surveillance in the wake of revelations about a far-reaching spying program by the U.S. National Security Agency. European Union justice and rights commissioner Viviane Reding said "The question has arisen whether the large-scale collection and processing of personal information under US surveillance programmes is necessary and proportionate to meet the interests of national security." The EU is also asking the US for changes to US legislation to match the legal redress offered in Europe; American citizens in Europe can go to the courts if they feel their rights are infringed but Europeans without right of residence in America cannot.

Use of an early mobile phone in Austria, 1964

When the EU / US arrangement to implement International Safe Harbor Privacy Principles were struck down by the European Court of Justice, a new framework for transatlantic data flows, called the "EU-US Privacy Shield", was adopted in July 2016.

In April 2014, the European Court of Justice declared invalid the EU Data Retention Directive. The Court said it violates two basic rights – respect for private life and protection of personal data. The legislative body of the European Union passed the Data Retention Directive on 15 December 2005.

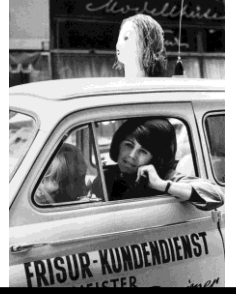
HIDE ("Homeland Security, Biometric Identification & Personal Detection Ethics") was a research project funded by the European Commission within the scope of the Seventh RTD Framework Programme (FP7).



Disaster response

The Finnish government decided in 2005 that the fastest way to warn citizens of disasters was the mobile phone network. In Japan, mobile phone companies provide immediate notification of earthquakes and other natural disasters to their customers free of charge. In the event of an emergency, disaster response crews can locate trapped or injured people using the signals from their mobile phones. An interactive menu accessible through the phone's web browser notifies the company if the user is safe or in distress.

Impact on society

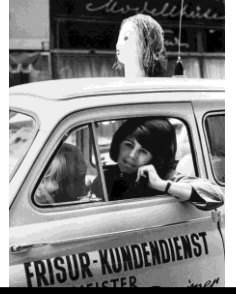


History of mobile telephony

Since the introduction of mobile phones, concerns (both scientific and public) have been raised about the potential health impacts from regular use. But by 2008, American mobile phones transmitted and received more text messages than phone calls. Numerous studies have reported no significant relationship between mobile phone use and health, but the effect of mobile phone usage on health continues to be an area of public concern.

For example, at the request of some of their customers, Verizon created usage controls that meter service and can switch phones off, so that children could get some sleep. There have also been attempts to limit use by persons operating moving trains or automobiles, coaches when writing to potential players on their teams, and movie theater audiences. By one measure, nearly 40% of automobile drivers aged 16 to 30 years old text while driving, and by another, 40% of teenagers said they could text blindfolded.

Between the 1980s and the 2000s, the mobile phone has gone from being an expensive item used by the business elite to a pervasive, personal communications tool for the general population



History of mobile telephony

In most countries, mobile phones outnumber land-line phones, with fixed landlines numbering 1.3 billion but mobile subscriptions 3.3 billion at the end of 2007.

In many markets from Japan and South Korea, to Europe, to Malaysia, Singapore, Taiwan and Hong Kong, most children age 8-9 have mobile phones and the new accounts are now opened for customers aged 6 and 7.
Because mobile phones are often used publicly, social norms have been shown to play a major role in the usage of mobile phones. Furthermore, the mobile phone can be a fashion totem custom-decorated to reflect the owner's personality and may be a part of their self-identity.
Mobile phone use can be an important matter of social discourtesy: phones ringing during funerals or weddings; in toilets, cinemas and theatres. Some book shops, libraries, bathrooms, cinemas, doctors' offices and places of worship prohibit their use, so that other patrons will not be disturbed by conversations.

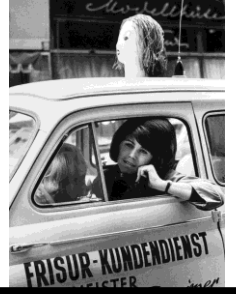
Mobile phone use while driving is common but it is dangerous due to its potential for causing distracted driving and subsequent crashes. Due to the number of crashes that are related to conducting calls on a phone and texting while driving

In the United States, automobile crashes due to distracted driving are increasing even after the passage of laws intended to lessen such use while driving. Using a cell phone while driving increases the driver's risk of causing a crash. Drivers can become distracted, decreasing the driver's awareness on the road, leading to more car crashes. When drivers talk on cell phones the risk of an automobile crash resulting in hospitalization is four times higher than when not talking on a cell phone. Drivers who text when behind the wheel are twenty-three times more likely to have an automobile crash. One out of every four automobile crashes in the United States are caused by texting while driving.

Use on aircraft

As of 2007, several airlines are experimenting with base station and antenna systems installed on the airplane, allowing low power, short-range connection of any phones aboard to remain connected to the aircraft's base station. Thus, they would not attempt connection to the ground base stations as during takeoff and landing.[citation needed] Simultaneously, airlines may offer phone services to their travelling passengers either as full voice and data services, or initially only as SMS text messaging and similar services. The Australian airline Qantas is the first airline to run a test aeroplane in this configuration in the autumn of 2007. Emirates has announced plans to allow limited mobile phone usage on some flights. However, in the past, commercial airlines have prevented the use of cell phones and laptops, due to the assertion that the frequencies emitted from these devices may disturb the radio waves contact of the airplane.

In April 2007 the US Federal Communications Commission officially prohibited passengers' use of cell phones during a flight



History of mobile telephony

Like all high structures, cellular antenna masts pose a hazard to low flying aircraft. Towers over a certain height or towers that are close to airports or heliports are normally required to have warning lights. There have been reports that warning lights on cellular masts, TV-towers and other high structures can attract and confuse birds. US authorities estimate that millions of birds are killed near communication towers in the country each year.

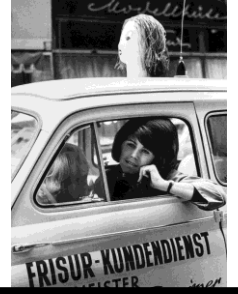
Some cellular antenna towers have been camouflaged to make them less obvious on the horizon, and make them look more like a tree.

Cellular antenna disguised to look like a tree

Payment methods

There are two principal ways to pay for mobile telephony: the 'pay-as-you-go' model where conversation time is purchased and added to a phone unit via an Internet account or in shops or ATMs, or the contract model where bills are paid by regular intervals after the service has been consumed. It is increasingly common for a consumer to purchase a basic package and then bolt-on services and functionality to create a subscription customised to the users needs.

Pay as you go (also known as "pre-pay" or "prepaid") accounts were invented simultaneously in Portugal and Italy and today form more than half of all mobile phone subscriptions.[citation needed] USA, Canada, Costa Rica, Japan, Israel and Finland are among the rare countries left where most phones are still contract-based.

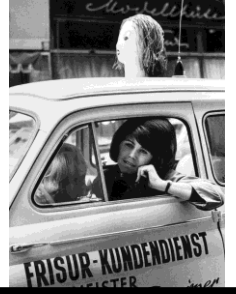


History of mobile telephony

In the early days of mobile telephony, the operators (carriers) charged for all air time consumed by the mobile phone user, which included both outbound and inbound telephone calls. As mobile phone adoption rates increased, competition between operators meant that some decided not to charge for incoming calls in some markets (also called "calling party pays").

The European market adopted a calling party pays model throughout the GSM environment and soon various other GSM markets also started to emulate this model.

In Hong Kong, Singapore, Canada, and the United States, it is common for the party receiving the call to be charged per minute, although a few carriers are beginning to offer unlimited received phone calls. This is called the "Receiving Party Pays" model. In China, it was reported that both of its two operators were to adopt the caller-pays approach as early as January 2007.
When a user roams in another country, international roaming tariffs apply to all calls received, regardless of the model adopted in the home country.



Technologies used

History of mobile telephony

0G (mobile radio telephone)
1G networks (analog networks)
2G networks (the first digital networks):
Digital AMPS
cdmaOne
GSM
GPRS
EDGE(IMT-SC)
Evolved EDGE

CDMA2000
OFDMA (air interface)
EVDO
SVDO

3G networks:
UMTS
W-CDMA (air interface)
TD-CDMA (air interface)
TD-SCDMA (air interface)
HSPA
HSDPA
HSPA+

4G networks:
LTE (TD-LTE)
LTE Advanced
LTE Advanced Pro
WiMAX
WiMAX-Advanced (WirelessMAN-Advanced)
Ultra Mobile Broadband (never commercialized)
5G networks:
5G NR
Starting with EVDO the following techniques can also be used to improve performance:

MIMO, SDMA and Beamforming